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Lawrence Livermore National Laboratory

Nuclear Accident Dosimetry Exercises at CEA-Valduc

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Outline

Topics

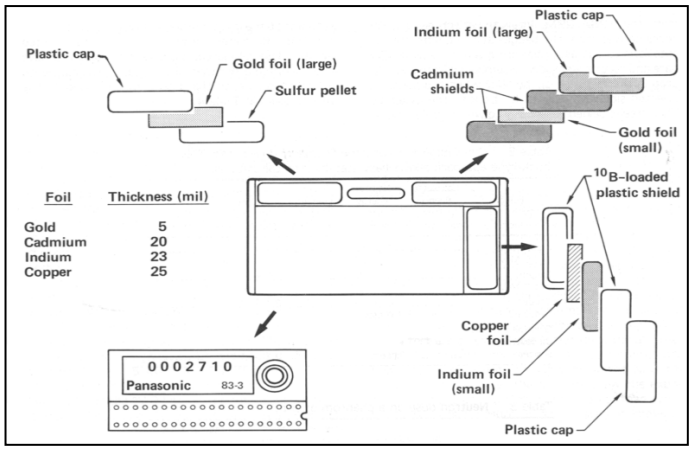
- 2009 SILENE Nuclear Accident Dosimetry Exercise
  - Preparation for Exercise
  - Exercise Setup Overview
  - Exercise Results
  - Lessons Learned
- 2010 CALIBAN Nuclear Accident Dosimetry Excerise
  - Preparation for Exercise
  - Exercise Setup Overview
  - Preliminary Results
- Future Work

2009 NAD Exercise Overview

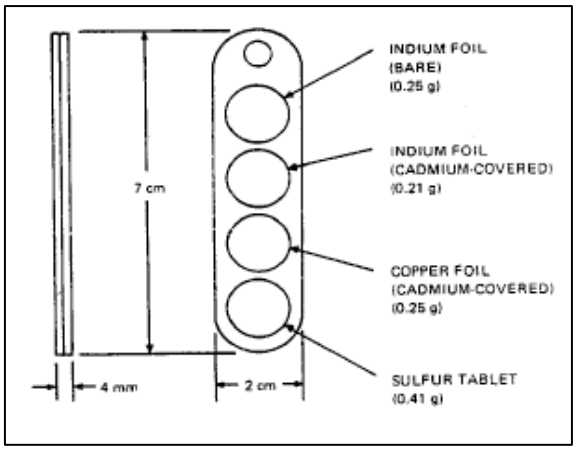
Participating Laboratories

LAWRENCE
LIVERMORE
NATIONAL
LABORATORY

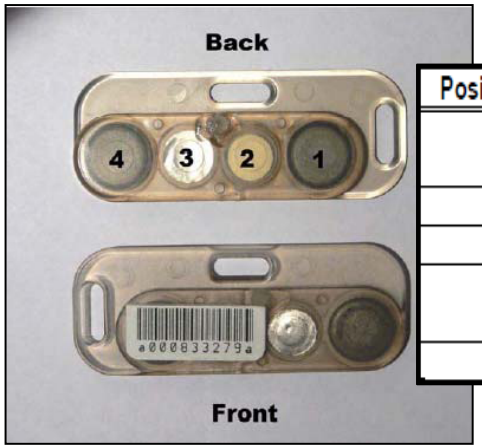
2009 NAD Systems



LLNL

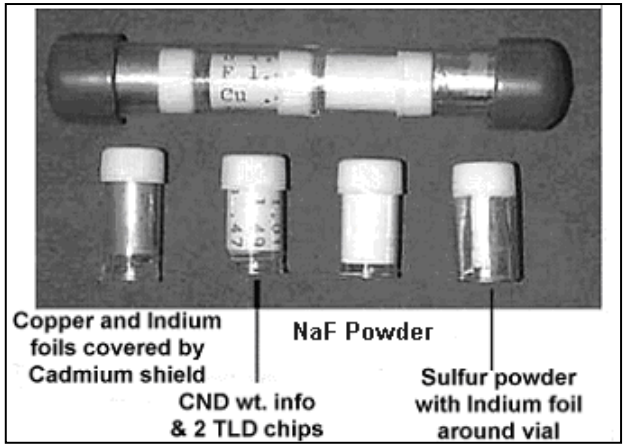


LANL



Position in PNAD	Description
1	Indium (Cd shielded)[(a)]
2	Sulfur Pellet
3	Indium (Bare)
4	Copper (Cd shielded)[(a)]
--	TLD-700 Chip

PNNL



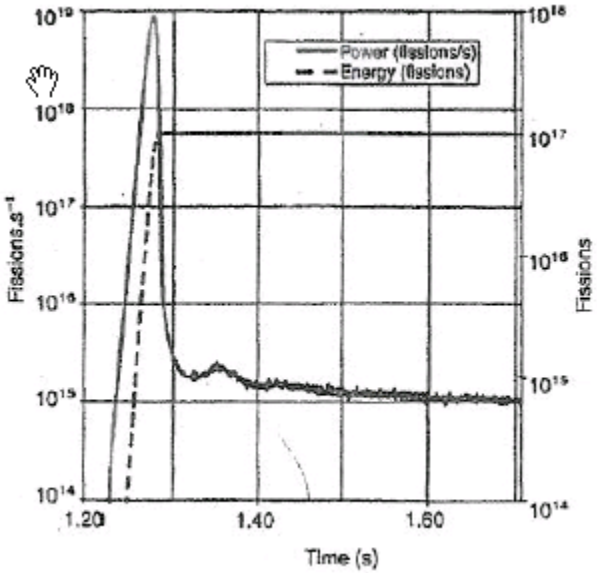
SRS

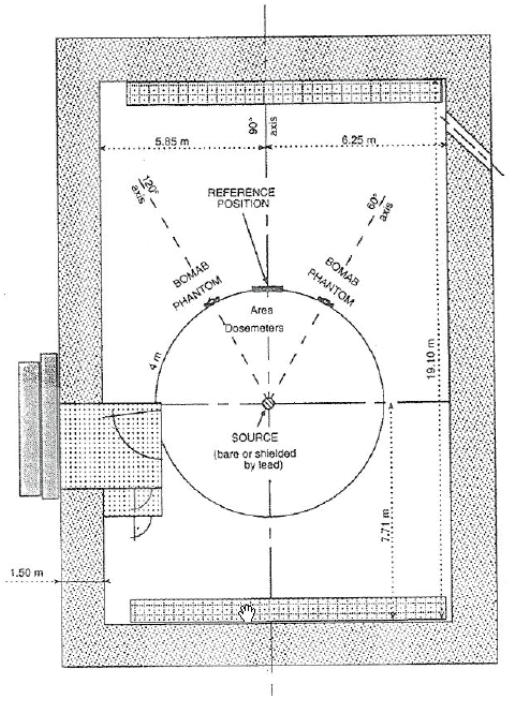
Note: Y-12 System Not Pictured

SILENE Reactor

SILENE Reactor

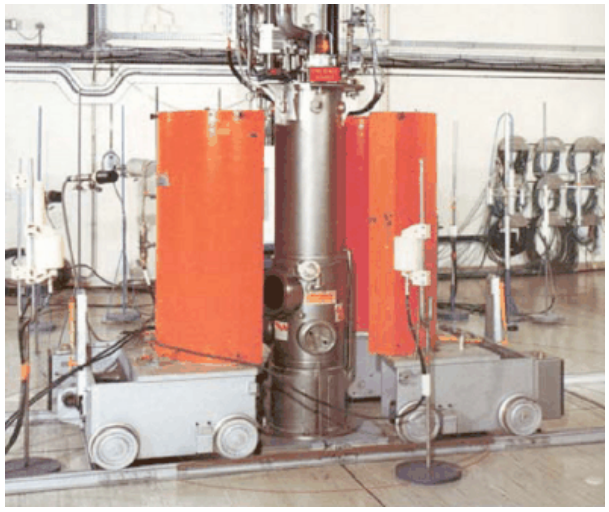
- Uranyl-nitrate solution reactor
- Operates in three modes: **pulse**, free evolution, steady state
- Pulse mode initiated by rapid withdrawal of control rod
- Reaction stops due to bubbling of liquid and then liquid is quickly evacuated from reactor core
- Operated bare and with a lead shield





Exercise Setup

- Three Pulses
  - Pulse 1 – Lead Shield
  - Pulse 2 – No Shield, High Yield
  - Pulse 3 – No Shield, Low Yield
- Phantom Arrangement
  - Setup at 2 m, 4 m, and 6 m distances
  - Bibs contained dosimeters on front, side, or rear of phantom



Exercise Results - Neutron

US Laboratory Exercise Results

Neutron Dose (Rad)

Pulse	Shield	Distance (m)	Valduc	LLNL	Y-12	LANL	PNNL	SRS
1	Lead	2	**690**	791	800	650	634	546
		4	**190**	232	290	270	NR	NR
		6	**110**	109	160	NR	NR	NR
2	None	2	**320**	344	340	310	367	425
3	None	6	**150**	159	180	150	78	154

Exercise Results – Neutron

US Laboratory Exercise Results

Relative Neutron Results to Given Values

Pulse	Shield	Distance (m)	Valduc	LLNL	Y-12	LANL	PNNL	SRS
1	Lead	2	1	1.15	1.16	0.94	0.92	0.79
		4	1	1.22	1.53	1.42	NR	NR
		6	1	0.99	1.45	NR	NR	NR
2	None	2	1	1.08	1.06	0.97	1.15	1.33
3	None	6	1	1.06	1.2	1	0.52	1.03

According to ANSI/HPS N13.3, *Dosimetry for Criticality Accidents,* nuclear accident dosimetry systems should be able to provide sufficient data to calculate the dose within ± 25%. Results in green meet this performance criterion while results in red do not.

Exercise Results - Gamma

Integrated US Laboratory Exercise Results

Gamma Dose (Rad)

Pulse	Shield	Distance (m)	Valduc	LLNL	Y-12	LANL	PNNL	SRS
1	Lead	2	**50**	221	180	420	276	262
		4	**30**	46	80	160	NR	NR
		6	**20**	28	50	NR	NR	NR
2	None	2	**380**	432	330	420	467	494
3	None	6	**210**	172	160	180	187	295

Exercise Results - Gamma

Integrated US Laboratory Exercise Results

Relative Gamma Dose Relative to Given Values

Pulse	Shield	Distance (m)	Valduc	LLNL	Y-12	LANL	PNNL	SRS
1	Lead	2	1	4.42	3.6	8.4	5.52	5.24
		4	1	1.53	2.67	5.33	NR	NR
		6	1	1.4	2.5	NR	NR	NR
2	None	2	1	1.14	0.87	1.11	1.23	1.3
3	None	6	1	0.82	0.76	0.86	0.89	1.4

According to ANSI/HPS N13.3, *Dosimetry for Criticality Accidents,* nuclear accident dosimetry systems should be able to provide sufficient data to calculate the dose within ± 25%. Results in green meet this performance criterion while results in red do not.

Lessons Learned

- **Insufficient Operational Experience**
  - Instrumentation and personnel have changed resulting in personnel with no practical experience
  - Training of dosimetry personnel on their dosimetry system should be formalized and increased across complex

- **Detector Technology Has Advanced**
  - Nuclear accident dosimetry technology is substantially unchanged
  - Neutron activation analysis imposes time restraints on short lived isotopes
  - Difficulty in accounting for complex power history
  - Measurements require expert interpretation
  - NAD systems could take advantage of current technology or new technology to eliminate process steps and lessen reliance on experts

- **Gamma Dose TLD Needs Investigation**
  - Results from all laboratories (particularly pulse 1 – 2m) were far too high
  - Additional testing is necessary to resolve this anomaly

Lessons Learned

- **Throughput of Activated Foils is the Limiting Factor**
  - Counting irradiated samples must be done before activation of sample becomes too low and information is gone
  - To achieve good statistics these counts require time
  - Crosstalk of samples due to multiple teams added an additional complication

- **A Thorough and Reoccurring Testing Program is Needed**
  - Every participating laboratory expressed a strong desire for continued opportunities to test and refine their dosimetry system as well as train operations personnel to demonstrate regulatory compliance and competency
  - ANSI/HPS N13.3 *Nuclear Accident Dosimetry* is being rewritten with these participating labs taking the lead

2010 CALIBAN NAD Exercise

Participating Laboratories

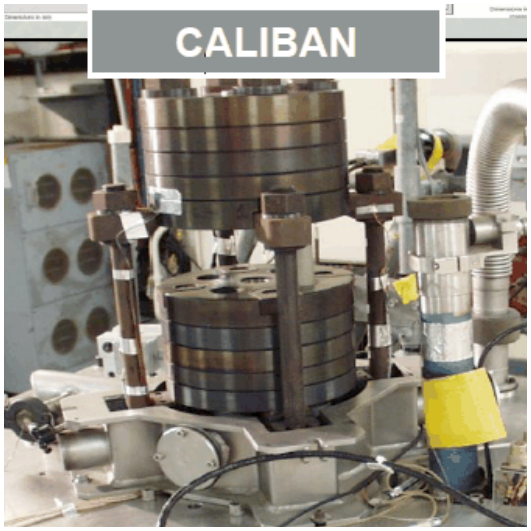
- All 2009 Participants Returned
  - LLNL
  - LANL
  - PNNL
  - SRS
  - Y-12
- New Participant

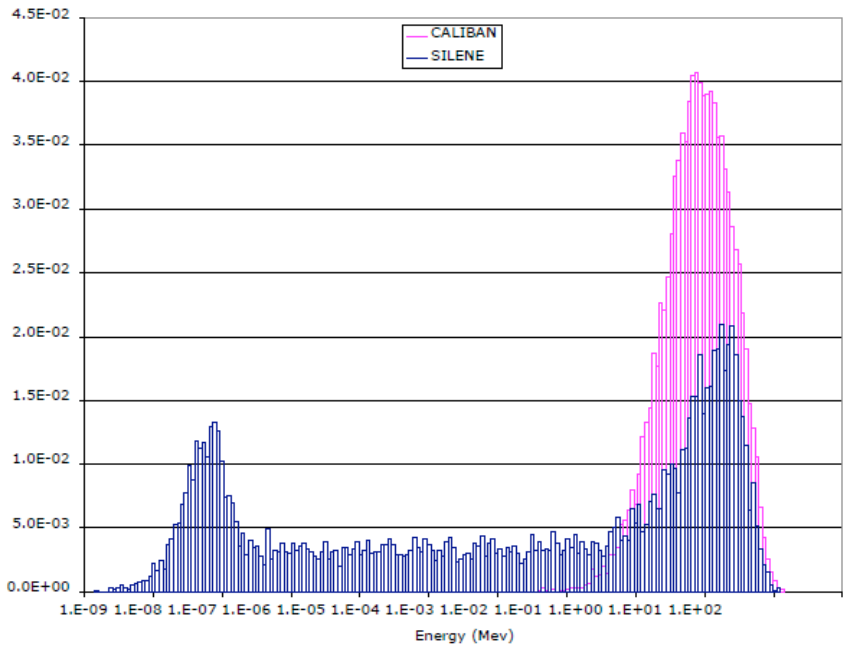
- Many other organizations expressed interest but could not be accommodated until exercises are established with Godiva

CALIBAN Reactor

CALIBAN Reactor

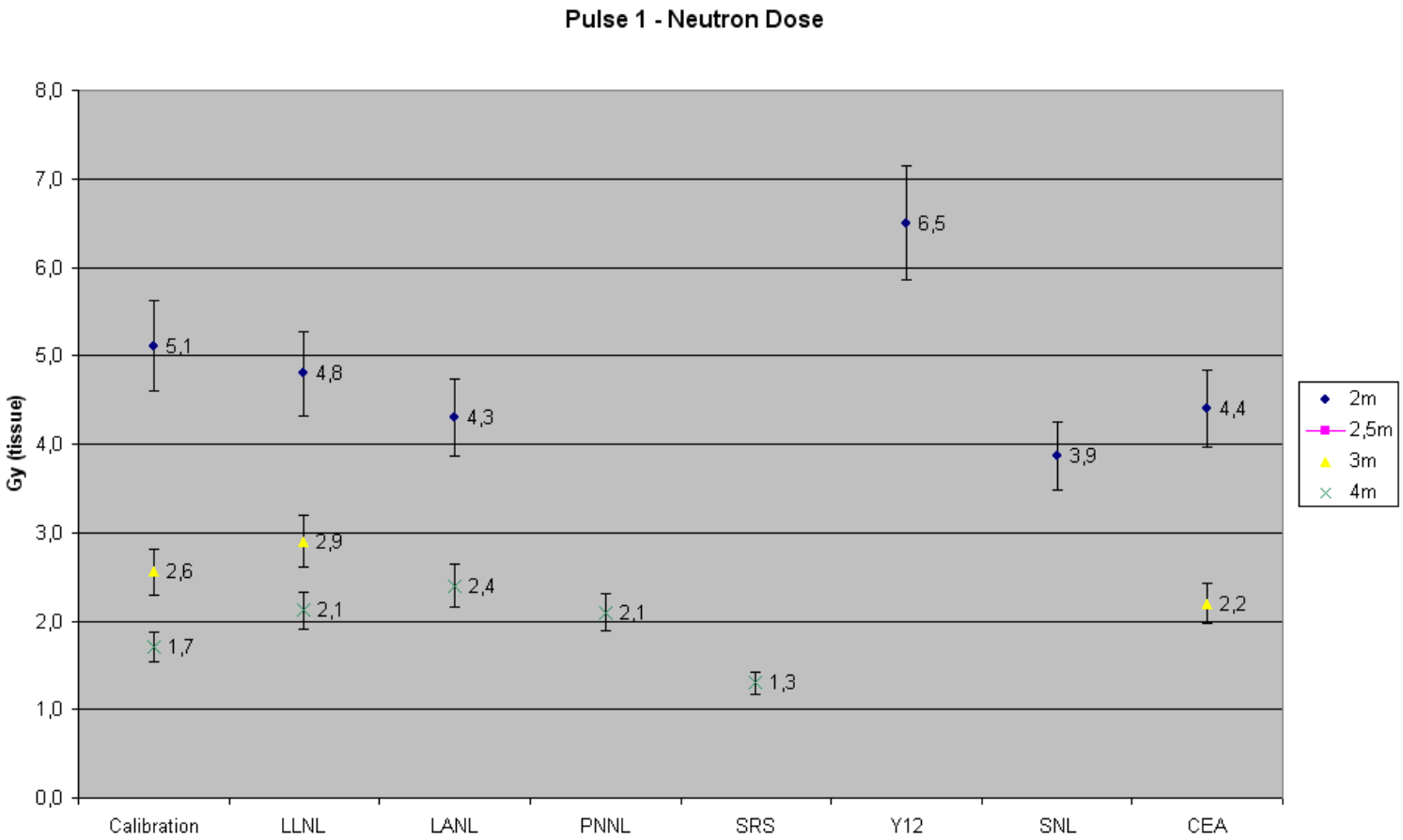
- Unreflected HEU metal fast burst reactor (similar to SPR)
- Operated in pulse mode
- Pulse mode initiated by rapid insertion of control rods
- Solid core composition
  - 10 fuel discs & 4 control rods
  - 93.5% HEU metal alloyed with 10 wt% Mo





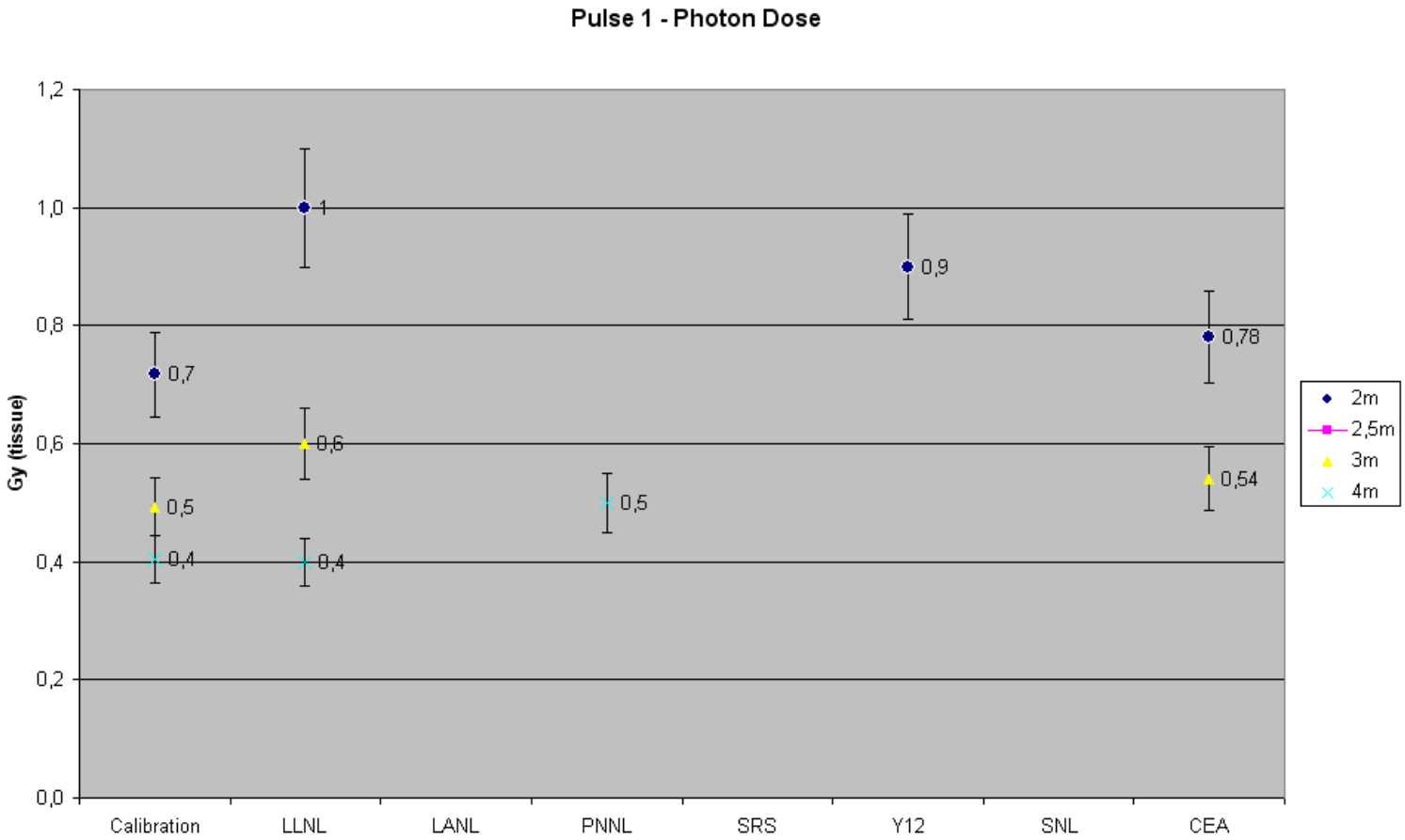
Preliminary Exercise Results

US Laboratory Exercise Results



Preliminary Exercise Results

US Laboratory Exercise Results



Note: PNNL and Y12 photon doses are estimated from published photon to neutron ratios. LLNL doses measured with ionization chambers.

Future NAD Exercises

- **2013 Godiva NAD Experiment at Nevada National Security Site (NNSS)**
  - **Laboratory participants were limited by equipment and setup available at CEA-Valduc**
  - **LLNL is coupling the experience of the past two NAD exercises in France with operational experience at NNSS to develop a counting laboratory for upcoming NAD experiments using Godiva.**
  - **Godiva radiation field in DAF must be characterized to provide reference values**
  - **Counting Laboratory will feature all the proper safety equipment, workspace, hand tools, and utilities (i.e. power)**
  - **Counting Laboratory should provide a fume hood to allow processing of irradiated dosimetry elements (e.g. crushing, melting, burning sulfur)**
  - **Counting Laboratory should include moveable shielding to minimize crosstalk**
  - **Routine exercises should be provided in the future for training of dosimetry personnel**
  - **NNSA should consider hosting an OECD International Intercomparison Exercise**